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# *Genipa americana* L. Jagua, genipa

## Rubiaceae Madder family

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**John K. Francis**

*Genipa americana* L. is also known by the common names jagua (Spanish), genipa (English), bois de fer (French), and genipapo (Portuguese) *(28)*. It is a medium-size tree (fig. 1) with a smooth, light-colored bark, straight trunk, whorled branches, dark-green leaves, and fruit having an odor and taste reminiscent of pears (*Pyrus communis* L.). The species has a wide natural range, part of it attributable to cultivation in pre-Columbian times. Jagua wood, which has many uses, is tan in color, even-textured, and moderately heavy.

## HABITAT

### Native and Naturalized Ranges

The jagua tree probably originated in the Amazon Basin and was spread throughout the American Tropics by humans in prehistoric times *(10)*. The original extent of the range is unknown. Today, jagua trees grow naturally along both coasts of Mexico slightly north of the Isthmus of Tehuantepec and from the isthmus throughout Central America *(7)* and through northern South America to Paraguay and northern Argentina *(20)* (fig. 2). The species is also found in the Greater Antilles (except on Jamaica) and on many of the islands in the Lesser Antilles *(3, 20)*.

### Climate

The jagua tree is restricted to warm, moist habitats. The natural distribution of the species is generally confined to areas receiving 1200 to 4000 mm of annual precipitation and having mean annual temperatures of 18 to 28 °C *(10)*. Although the jagua tree probably does best in a continually moist habitat, some parts of the natural range have dry seasons of up to 5 months in length *(34)*, during which it loses its leaves, which helps the tree avoid drought stress. Growing in riparian habitats probably enables the species to exist in a somewhat drier overall habitat than it could normally withstand. It is not subject to frost in its native habitat and is injured by temperatures a few degrees above freezing *(22)*.

### Soils and Topography

Jagua trees grow on a wide variety of soil types in moist areas. The species requires acid soils and has prospered in plantations in areas having soils with a pH as low as 4.6 *(36)*. It may inhabit alluvial sites in areas with igneous parent materials and in well-weathered soils over limestone. The species is rarely found on sands or near beaches. Some of the largest trees develop in inland marshy areas *(8)*. In the Amazon Basin, it is reported to grow along clear and muddy rivers but not along black-water rivers *(10)*. Jagua trees seldom grow in upland soils, but those that do are usually shorter than trees grown on bottomland sites. The species grows naturally on sites up to 1,500 m in elevation in Colómbia *(30)*.

Jagua seedlings were test planted on the edge of a Brazilian reservoir that flooded frequently. The plants survived at rates ranging from 6 to 100 percent after 1 year, depending on the severity of flooding. The most severely impacted seedlings were flooded for 174 days, including days of total submersion *(12)*.

### Associated Forest Cover

Across its large range, the jagua tree grows in association with many species; two examples are given here. On a riverbank site in the Atrato Valley in Colómbia, jagua trees may be found growing with *Artocarpus altilis* (Parkinson) Fosberg, *Cecropia* sp., *Cedrela* sp., *Cespedesia macrophylla* Seem., *Guilielma gasipaes* (H.B.K.) Bailey, *Gustavia superba* Berg, *Inga* sp., *Luehea seemannii* Planch. & Triana, *Parkia* sp., *Pithecellobium* sp., *Vismia* sp., and *Vochysia* sp. *(15)*. In Puerto Rican forests, jagua is usually confined to

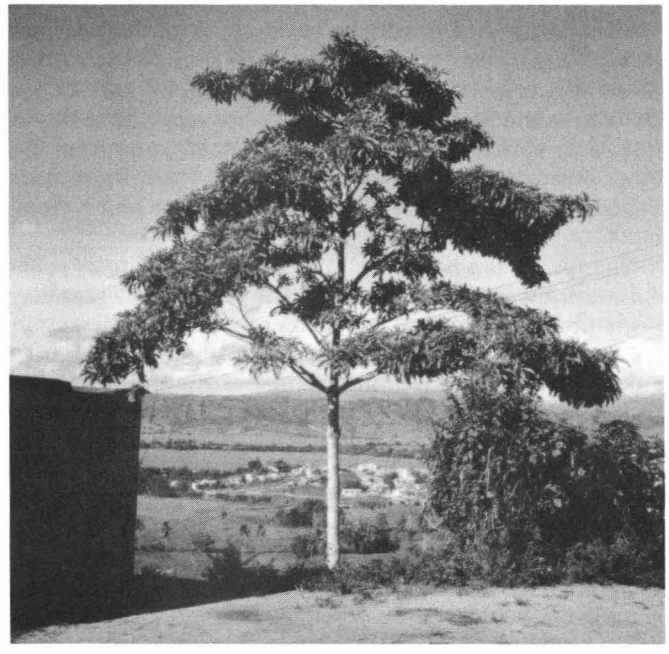

**Figure 1.** — *Young jagua* (Genipa americana) *tree growing in Puerto Rico.*

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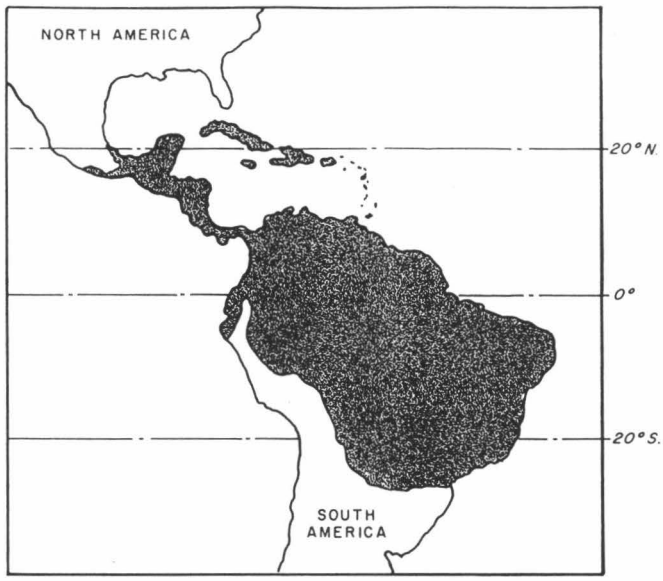


**Figure 2.** — *The approximate combined native and naturalized ranges of the jagua* (Genipa americana) *tree.*

former subsistence farmland. Frequently associated with the species are *Mangifera indica* L., *A. altilis, Andira inermis* (W.Wright) DC., *Tabebuia heterophylla* (DC.) Britton, and *Guarea guidonia* (L.) Sleumer (author, personal observation).

## LIFE HISTORY

### Reproduction and Early Growth

**Flowering and Fruiting.**—Large (3.8-cm) pale-yellow flowers are borne in clusters at the ends of branches. Generally, only one fruit develops per cluster *(18).* Jagua trees from the State of Pará, Brazil, are reported to flower from July through December and to yield fruits from October through June *(27).* This species in Haiti fruits from September to January, with a peak in October and November.[1]

The species is a heavy fruit producer; trees 15 to 20 years old sometimes produce 400 to 600 fruits per year. Trees may begin producing fruits 6 to 8 years after the seedling stage *(10, 11).* Six trees of natural stock and six trees of grafted stock in Brazil produced an average of 7.6 and 11.2 kg of fruit per tree per year, respectively *(27).*

**Seed Production and Dissemination.**—Jagua fruits from Brazil are reported to have yielded an average of 266 seeds per fruit. The seeds weighed an average of 0.078 g per seed, and there were 12,800 seeds per kilogram *(27).* One sample of seeds from Puerto Rico averaged 14,770 seeds per kilogram *(21).* Seeds in another sample from Puerto Rico averaged 0.050 g per seed or 20,000 seeds per kilogram (author, personal observation). Fresh seeds retain viability for 3 months at ambient temperature *(29).* Large quantities of seeds can be extracted from fallen fruit.

Seeds in the feces of monkeys (species not specified) and coyotes *(Canis latrans)* have been noted in Costa Rica *(16).* Probably a large number of wild and domestic mammals, birds, and bats aid in seed dispersal.

**Seedling Development.**—Germination of jagua seeds is epigeous. A batch of seeds sown on peat germinated at the rate of 60 percent, beginning 25 days after sowing and continuing for 2 months (author, personal observation). Shade seems to be beneficial to seedlings at first, and good protection against drought is required. Seedlings have proved difficult to produce in the nursery. More than half of one batch of seedlings in Puerto Rico developed a chlorosis that proceeded to kill most of the seedlings displaying symptoms. Only the leaves were affected at first, leaving the stem and root intact but unable to sprout and regrow. In a few cases, the leaves regained their green color, and the plants resumed growing (author, personal observation). This condition was also observed in a nursery in Haiti, where it proved impossible to grow seedlings in a locally produced potting medium made from soil, sugarcane bagasse, and rice hulls. The symptoms were diagnosed as a nutrient deficiency resulting from a sensitivity to alkaline soil or irrigation water.[1] The problem was eliminated by planting seedlings in peat moss.

Jagua seedlings grow rather slowly at first. They are reported to take 1 year to reach a plantable size of 20 to 40 cm *(10).* A batch of seedlings produced by the author reached an average height of 28 cm 17 months after sowing. The period probably could have been shorter if the nutritional problems mentioned earlier had been avoided. Because of a sensitivity to drought, planting containerized seedlings is probably the only practical method for establishing the species. Removal of plastic nursery bags is optimal; the seedlings must be removed with their earth ball from pots. Planting in the field at spacings of 10 by 15 m is recommended for fruit production *(10).* Plantings for timber production should be much closer together, about 3 by 3 m, to promote natural pruning. A combination of timber and fruit objectives seems perfectly logical and would involve growing the tree initially at close spacings until a clear bole is set and a minimum marketable size is reached. The trees would then be thinned to wide spacings to allow them to develop large crowns for fruit production and at the same time ensure a rapid increase in the diameters of the remaining stems. Epicormic branches will not develop. After 20 or 30 years of fruit production, the large trees would be harvested for sawlogs.

When growth of seedlings planted in full sunlight and seedlings planted in partial shade created by selective cutting were compared at 36 months of age, the plants had grown to average heights of 4.1 and 2.5 m, respectively. Both treatments had 92-percent survival *(4).* At 4.3 years of age, the same seedlings grown in full sun averaged 9.5 m in height and 13.5 cm in diameter at breast height (d.b.h) *(36).* In another planting in the Tapajos National Forest in Brazil, seedlings 32 months old averaged 3 m in height and 3.6 cm in d.b.h. and had a survival rate of 84 percent *(37).* Jagua seedlings planted in a block on a moist (1600 mm of annual precipitation) savanna site in Venezuela averaged 3

[1]Timyan, Joel. Auburn University, School of Forestry, Auburn, AL 36849. Personal communication with author.

m in height at 5 years and had 88-percent survival *(11)*. Jagua seedlings planted in a species comparison experiment in Río Cauca, Colómbia, had an average height of 5.2 m, an average d.b.h. of 4.2 cm, and a survival of 80 percent after 3.5 years *(5)*. Four small experimental plantings on upland sites were made in Puerto Rico. Initial survival was good; however, after 10 years, survival was only 12 to 40 percent, and the average tree heights on the plots ranged from 1 to 5 m.

**Vegetable Reproduction.**—The species may be propagated by bud grafting and air layering *(10, 22)*. Seedlings and saplings will coppice if cut.

### Sapling and Pole Stage to Maturity

**Growth and Yield.**—Although generally a small tree (sometimes a shrub) on abandoned farms and in upland and riparian forests, the jagua tree can reach over 30 m in height and more than 0.5 m in d.b.h. in swamp forests in Guyana *(8)*. Mature trees in Puerto Rico are generally 10 to 25 m in height and up to 0.5 m in d.b.h. The species grows according to the Fagerlind model of tree architecture in which a straight monopodial leader sets spaced whorls of branches *(14)*. The jagua tree tends to have a clear bole to the base of a crown of heavy branches.

Jagua trees in a 9-year-old plantation in the State of Minas Gerais, Brazil, averaged 12.2 cm in d.b.h. and 8.7 m in height and yielded an annual average of 19.8 $m^3$/ha and 13.1 dry tons of wood per hectare *(25)*. At 49 years of age, two trees that had been planted in a subtropical wet forest in Puerto Rico measured 53 and 43 cm in d.b.h. and 18 and 28 m in height, respectively (author, personal observation). The species probably could be successfully managed for sawlogs in plantations, but the difficulties of establishment, the slow growth rate, and the moderate value of the wood probably do not justify the effort and expense that would be required.

**Rooting Habit.**—Jagua seedlings produce long, slender taproots; larger trees tend to be deep rooted *(1)*. The base of the tree is not buttressed.

**Reaction to Competition.**—Despite massive seed production and wide dispersal, few seedlings become established. Apparently, germination under natural conditions is low or mortality is massive soon after germination; few advanced seedlings are seen in the wild. The jagua tree is intolerant of heavy shade and probably requires a reduction of the vegetative cover to become established. The species is rarely more than a minor component in primary forests, usually growing as solitary trees. In Brazil and Venezuela, density of overstory trees may vary from one or two per hectare to one in several hectares *(23, 33)*. In contrast, the species is common on former agricultural land, especially near current or former dwellings. Almost all the jagua trees in Puerto Rico are on present or former subsistence farms (author, personal observation). Jagua seedlings grew very slowly when planted in a mixture with the fast-growing leguminous tree *Senna siamea* (Lam.) Irwin & Barnaby *(11)*. The crown ratios of nine trees selected for superior phenotypic qualities in Haiti, ranging from 20 to 57 cm in d.b.h., averaged 22 percent.[1]

**Damaging Agents.**—A number of coleopteran, homopteran, and lepidopteran insects are reported to use the species as a host, although none appears to cause serious damage *(10, 23)*. Logs are susceptible to several genera of pinhole borers but are resistant to sap-stain fungi under normal circumstances *(19)*. The wood in use (construction, etc.) is very susceptible to attack by the dry-wood termite *Cryptotermes brevis* (Walker) *(31, 35)*. The jagua tree has little resistance to powderpost beetles (*Lyctus* spp.) or to marine borers (*Toreda* spp.) *(7)*. The wood is subject to rot and should not be used in contact with the ground.

## SPECIAL USES

Sapwood of the jagua tree is cream-colored merging gradually into a light-tan heartwood that sometimes has a slight pink or blue overcast. A minor amount of figure is evident in some pieces. The wood has a medium luster and a fine texture *(19)*.

The wood air-seasons slowly, resulting in only minor warping and virtually no surface checking *(6)*. Shrinkage during air-drying of 1.7 to 5.0 percent radially, 4.1 to 9.1 percent tangentially, and 13.5 to 23.3 percent volumetrically is reported *(2, 6, 19, 24)*.

A range of densities is reported for jagua wood. Samples of wood from Brazil, Puerto Rico, and Venezuela are reported to have had densities of 0.68 g/$cm^3$ (15-percent moisture) *(24)*, 0.82 g/$cm^3$ (ovendry) *(19)*, and 0.70 g/$cm^3$ (12-percent moisture), respectively *(2)*. Heartwood samples taken by the author from a Puerto Rican tree averaged 0.60 g/$cm^3$. Wood densities, presumably air-dry, from Guyana are reported to have ranged from 0.67 to 0.83 g/$cm^3$ *(8)*. Strength properties of Brazilian samples (15-percent moisture) and Venezuelan samples (12-percent moisture) are reported as follows: modulus of rupture, 1,004 and 937 kg/$cm^2$; and modulus of elasticity, 65,000 and 120,000 kg/$cm^2$ *(2, 24)*. Dimensions and properties of the wood fibers of the species have been published *(7)*.

Wood of the jagua tree machines better than many premier cabinet woods such as mahogany and teak. It also stains and finishes well, glues satisfactorily, and has good screw-splitting resistance *(19)*. Uses of the wood include shoe lasts, tool handles, turnery, bentwood, furniture, cabinetry, flooring, veneer, and plywood *(6)*. At present, the wood is sold only in local markets. Undoubtedly, the species would be of major importance if more volume were available.

Fruit of the jagua tree was an important food in prehistoric and historic times. Of minor importance now, the fresh fruit is consumed to a limited extent in rural areas. Many people find the taste unpleasant *(10)*. The flavor may be described as mildly (stronger in some areas) acidic, similar to pears or dried apples, with a slightly soapy or putrid aftertaste (author, personal observation). The fruit is more often used in preparing juice, jelly, candied fruit, and liquor *(10)*. The jagua fruits fall to the ground without bruising when ripe and are gathered from under bearing trees *(10)*. The mesocarp of the fruit contains (incomplete analysis) 73 percent water, 13 percent sugar, 8 percent cellulose, 1 percent ash, 0.72 percent tartaric acid, and 0.35 percent essential oils *(10)*.

Fruit of the species is consumed by wildlife and livestock *(16, 18)*. Also, the flowers are a source of nectar for

honeybees *(17)*. The bark contains 70 percent tannin and should be suitable for curing leather *(24)*. Other minor uses for the tree include pasture shade, live fenceposts, and fuelwood.

At the time Europeans arrived, Indians in the West Indies and South America were using juice from green fruit of the jagua tree to dye their bodies. Treated areas turned black on exposure to the sun and remained dark for 12 to 15 days *(9)*. The active agent, an iridoid genipin, reacts with protein to produce the dark color *(13)*. This body dye is still used in remote areas of South America. Also, it was formerly used commercially to impart a blue-black color to cloth *(28)*.

Juice from immature fruits of the jagua tree is reported to cure small wounds and ulcers *(10)*. A preparation from the tree is reputed to be the only natural substance capable of removing the tiny South American parasitic fish *(Vandellia* sp.) that enters human orifices *(20)*.

## GENETICS

Botanical synonyms are *G. oblongifolia* R.& P., *G. excelsa* Krause, and *G. americana* var. *caruto* Schum. *(26, 30)*. *Genipa caruto* H.B.K., another American species, is closely allied with the jagua tree and differs from it in having densely pubescent leaves *(28)*; some botanists consider them to be forms of the same species *(32)*.

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